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SOME NEW GREGARINE PARASITES FROM ARTHROPODA *

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For several years I have been studying a number of gregarines parasitic in various arthropods. The literature apparently contains no record of most of them and consequently they are here described as new species. A few of the species studied were already known, but I am able to give new records on distribution and additional data on biology and life-history. Careful attention was devoted to the biology of the forms studied and extended experiments were conducted on life-history problems. In this paper is presented a brief account of these studies, which will be published in full at a later date. Especial attention is called here to the observations on movement in gregarines and on cyst formation. The descriptions of new species though concise have been worked over so carefully that it is thought they will be ample for accurate determinations.

BIOLOGICAL OBSERVATIONS

The polycystid gregarines have a septum which divides the cell into two or more distinct compartments, and the species described in this paper are all of this type. Polycystid gregarines inhabit chiefly the mid-intestines and intestinal diverticula of arthropods and are often found in large masses comprising many hundred parasites. In some genera the adult animals are solitary; in others they are attached one behind the other. Most of the latter are biassociative, but a few genera occur in chains of from three to ten or twelve individuals.

The sporonts, or adult animals, move about freely in the lumen of the intestines or lie inert between the lobes. The trophozoites, or young individuals, live either entirely within the epithelial cells, as in the family Stenophoridae, or attached to the free ends of the cells by means of variously shaped epimerites, globular in the genus *Gregarina*. When a trophozoite has absorbed sufficient nourishment from the host cell, either directly through its walls or by means of the epimerite, it breaks forth from the shriveled cell and becomes a sporont, living free in the intestine, and the useless epimerite, if present, is gradually lost. The animal now receives its food entirely by absorption of the digestive juices direct from the host intestine.

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Movement of the free individuals takes place by a gradual progression and by bending of any part of the deutomerite. There are two structures necessary for motion. Running crosswise in the outer part of the endocyte is a delicate network of fibrillae, the myonemes, sometimes seen with a rather low power in individuals nearly devoid of protoplasm. In the outer portion of the epicyte, the outside layer of the body, there are found very fine longitudinal striations visible only with an oil-immersion lens. In the furrows between these striations there are minute pores (Schewiakoff, 1894) through which a gelatinous material is exuded. The animal progresses by contracting a few myonemes on that side of the body which happens to be ventral and this causes a minute undulatory motion against the slide. At the same time the animal secretes mucus, which enables it to move forward against friction, much as a slug moves forward by a wave-like motion on its ventral side. The trail of mucus left on the slide is the now useless material which has gradually been pushed backward through the longitudinal furrows by the progressing animal. Bending movement is effected by a contraction and expansion of the myonemes in any part of the deutomerite.

As the beginning of cyst-formation, two individuals, either associative or solitary, commence to revolve in a large circle. If the animals are solitary, an individual is drawn into the vortex of one which has started to revolve alone. If of a biassociative type, the two commence to revolve together. The spiral gradually becomes smaller as they continue in motion and the animals come to lie in contact laterally. Motion still continues and becomes rotary. As the two sporonts are forming a compact sphere, a thick, transparent covering is being laid down on the outside of the cyst which consists of as many thin layers of gelatinous material exuded from the posterior end of the moving animals as there are rotations before the animals come to rest. The fully formed cyst, sometimes still rotating, now passes from the mid-intestine of the host to the rectum and is given out with the feces.

Finding suitable moisture, the cyst develops within from 24 to about 48 hours with the formation and growth in many genera of as many as fourteen enormously long spore ducts. Each sporont breaks up into gametes, the gametes from one sporont uniting when fully formed with those from the other to form zygotes; and when the resultant spores have become mature they are forced out violently through the spore ducts into the surrounding medium. They become scattered and if accidentally eaten by an insect of the same species as the host, the outer spore wall is dissolved in the intestine, releasing eight active sporozoites. The latter pass to the epithelial cells

and either become attached or completely embedded, when the life-cycle begins anew.

There is evidence to indicate that auto-infection may occur by the cysts ripening in the intestine, and this would account for the enormous number of parasites often found within a single host.

The arthropods from which the parasites were taken include the Diplopoda, Orthoptera and Coleoptera, and the species are grouped in this order in the text. The gregarines described are members of the following genera: *Amphoroides*, *Steinina*, *Stenophora*, *Gregarina*, and a new genus which is here designated *Leidyana*.

GREGARINES IN THE DIPLOPODA

Infection in the diplopods is fairly heavy and about three fourths of the individuals examined at Urbana were parasitized. Parasites were abundant in the early spring as well as in the fall. Some species were nearly always found to be infected, others never.

Stenophora diplocorpa n. sp. (Fig. 1): Sporonts solitary, elongate. Maximum length 360μ , width 15μ . Ratio, length protomerite: total length : : 1:16 to 1:25. Ratio, width protomerite: width deutomerite : : 1:2 to 1:3. Protomerite dome shaped, widest at posterior margin and as wide as long. Slight constriction at septum. Deutomerite slender, elongate, incompletely divided into two nearly equal parts by a crosswise constriction, widest just anterior to this constriction. Cylindrical behind the constriction and broadly rounded at posterior end. Protomerite nearly transparent, deutomerite pale tan, not opaque. Nucleus visible in vivo, situated just behind constriction in the deutomerite, spherical, and containing one karyosome. Cyst and spores unknown.

Taken at Urbana, Illinois. Host: *Euryurus erythropygus* (Brandt). Habitat: intestine.

Stenophora impressa n. sp. (Fig. 2): Sporonts solitary, ellipsoidal. Maximum length 375μ , width 48μ . Ratio, length protomerite: total length : : 1:12. Ratio, width protomerite: width deutomerite : : 1:2.3. Protomerite conical, dilated in posterior half, as wide as high. An apparent pore at anterior end. Constriction at septum not deep. Deutomerite ellipsoidal, widest through central part, posterior extremity blunt or rounded. Endocyte of protomerite nearly transparent, of deutomerite opaque. Nucleus spherical with one large karyosome. Cysts spherical, 160μ in average diameter. Spores not known.

Taken at Urbana, Illinois. Host *Parajulus impressus* (Say). Habitat: intestine.

Stenophora lactaria n. sp. (Fig. 3): Sporonts solitary, elongate, ellipsoidal. Maximum length 480μ , maximum width 39μ . Ratio,

length protomerite: total length : : 1:10 to 1:16. Ratio, width protomerite: width deutomerite : : 1:1.2. Protomerite conical, dilated above base and tapering to a point. An apparent pore at apex. As broad as high. Constriction at septum. Deutomerite ellipsoidal, widest in anterior third, tapering to an acute, rounded extremity. Endocyte of protomerite nearly transparent, of deutomerite opaque. Nucleus ellipsoidal, twice as long as wide. Cysts spherical, 150 to 170 μ in diameter. Spores not known.

Taken at Urbana, Illinois. Host: *Callipus lactarius* (Say). Habitat: intestine.

Amphoroides calverti (Crawley) (Fig. 4): Sporonts solitary, elongate. Maximum length 1670 μ , average length 1400 μ , average width 120 μ . Ratio, length protomerite: total length : : 1:47. Ratio, width protomerite: width deutomerite : : 1:2.5 to 1:3. Protomerite greatly compressed in sporonts, shallow, five times as wide as high. Deep crater within top. Constriction at septum sharp and deep. Deutomerite elongate, widest in anterior third, tapering to a sharp point. Endocyte of protomerite tan in color, not dense; of deutomerite opaque, white. Nucleus small, spherical, not visible in vivo. Myocyte well developed. Cysts spherical, averaging 380 μ in diameter. Dehiscence by simple rupture. Spores not known.

Taken at Urbana, Illinois. Host: *Callipus lactarius* (Say). Habitat: intestine.

This species was described by Crawley (1903a) as *Gregarina calverti*, but the elongate shape of the sporonts, great size, dehiscence of the cysts by simple rupture, and the fact that all the animals are solitary prove that the species is not a member of the genus *Gregarina*. I place it in the genus *Amphoroides* because of the crateriform protomerite.

GREGARINES IN THE COLEOPTERA

The following nine species have been found in beetles and beetle larvae in the two general localities mentioned. In no instance has a complete life-history been established, but the generic position is determined beyond doubt by known characters. The members of the genus *Gregarina* are superficially very similar, but a close inspection yields points of difference sufficient to indicate the individuality of each species. While the primitives of several species are similar, the satellites are dissimilar and afford one means of differentiation. The relative sizes of the species and the color and density of the protoplasm afford other means of identification. The visibility of the nucleus is important in identification. The literature has been carefully investigated in the anticipation that some of the species, especially those in

the Elateridae and the Tenebrionidae had been previously described. All are, however, new.

Gregarina katherina n. sp. (Fig. 5): Sporonts biassociative, ellipsoidal. Length of associations 96 to 150 μ . Sporonts 45 to 70 μ long, 20 to 34 μ wide. Ratio, length protomerite: total length primate :: 1:6. Ratio, width protomerite: width deutomerite :: 1:7. Protomerite of primate dome shaped, of satellite flattened. Deutomerite ellipsoidal. Nucleus spherical, one large karyosome. Epimerite large, sessile, a hyaline knob. Cyst and spores not known.

Taken at Oyster Bay, Long Island, N. Y. Host: *Coccinella novum-notata* Herbst. Habitat: intestine.

Gregarina barbarara n. sp. (Fig. 6): Sporonts biassociative, ovoidal to subspherical. Length of association (average) 250 μ . Sporonts (primites) average 145 μ long, 90 μ wide. Ratio, length protomerite: total length primate :: 1:6. Ratio, width protomerite: width deutomerite :: 1:2.2. Protomerite hemispherical in primate, flattened in satellite, six times as wide as high, deutomerite ovoidal in primate, widest part in central region. Deutomerite of satellite widest in anterior third, no constriction at septum, contour here perfectly smooth. Nucleus small, spherical, with one karyosome. Body practically transparent. Cyst and spores not known.

Taken at Oyster Bay, Long Island, N. Y. Host: *Coccinella* sp. Habitat: intestine.

Gregarina globosa n. sp. (Fig. 7): Sporonts biassociative, subglobose. Length of associations 435 μ . Length of sporonts 260 μ , width 180 μ . Ratio, length protomerite: total length :: 1:8.6. Ratio, width protomerite: width deutomerite :: 1:2.4. Protomerite hemispherical, broadest at base, no constriction at septum. Deutomerite nearly spherical. Protoplasm dense, dark gray to black in primate, lighter in satellite. Nucleus spherical. Cyst and spores not known.

Taken at Urbana, Illinois. Host: *Coptotomus interrogatus* Fab. Habitat: intestine.

Gregarina monarchia n. sp. (Fig. 8): Sporonts biassociative, elongate cylindrical. Length of associations 570 μ , width 130 μ . Ratio, length protomerite: total length :: 1:7. Ratio, width protomerite: width deutomerite :: 1:1.2. Protomerite subspherical, widest through middle portion, constriction at septum. Deutomerite elongate cylindrical, equal in width throughout, broadly rounded posteriorly. Deutomerite dense, black in transmitted light. Protomerite nearly transparent. Nucleus not visible in vivo. Cyst and spores not known.

Taken at Urbana, Illinois. Host: *Pterostichus stygicus* Say. Habitat: intestine.

Gregarina intestinalis n. sp. (Fig. 9): Sporonts biassociative, broadly ellipsoidal. Length of associations 320μ . Maximum length of sporonts 160μ , maximum width 80μ . Ratio, length protomerite: total length :: 1:5. Ratio, width protomerite: width deutomerite :: 1:2. Protomerite subspherical, widest through middle portion, deep constriction at septum. Deutomerite broadly ellipsoidal, protoplasm dense, dark gray. Nucleus not visible in vivo. Cyst and spores not known.

Taken at Urbana, Illinois. Host: *Pterostichus stygicus* Say. Habitat: intestine.

Gregarina gracilis n. sp. (Fig. 10): Sporonts biassociative, elongate ellipsoidal. Maximum length of associations 370μ ; maximum length of sporonts 190μ , maximum width 75μ . Ratio, length protomerite: total length :: 1:8. Ratio, width protomerite: width deutomerite :: 1:2. Protomerite hemispherical. Deutomerite elongate ellipsoidal. Color gray. Nucleus not visible in vivo, spherical, small, with one karyosome. Cysts average 90μ in diameter. Spores not known.

Taken at Urbana, Illinois. Host: larvae of *Elateridae*. Habitat: intestine.

Gregarina tenebrionella n. sp. (Fig. 11): Sporonts biassociative, subglobose, very small. Maximum length of association, 140μ , average length 125μ . Ratio, length protomerite: total length :: 1:4. Ratio, width protomerite: width deutomerite :: 1:1.7. Protomerite dome shaped, deutomerite nearly spherical in primate, ellipsoidal in satellite. Nucleus small, spherical. Protoplasm gray. Cyst and spores not known.

Taken at Urbana, Illinois. Host: larvae of Tenebrionidae. Habitat: intestine.

Gregarina fragilis n. sp. (Fig. 12): Sporonts biassociative, ellipsoidal. Length of associations 200μ . Maximum length of sporonts 110μ , maximum width 60μ . Ratio, length protomerite: total length primate :: 1:5. Ratio, width protomerite: width deutomerite :: 1:2. Protomerite dome shaped, cylindrical in posterior third. Protomerite of satellite same shape but slightly flattened anteriorly. Deutomerite ellipsoidal. Nucleus small, spherical, with one karyosome. Body practically transparent. Cyst and spores not known.

Taken at Urbana, Illinois. Host: *Coccinella* sp. Habitat: intestine.

Steinina rotunda n. sp. (Fig. 13): Sporonts solitary, globose. Maximum length 250μ , maximum width 130μ . Ratio, length protomerite without epimerite: total length :: 1:2.3. Ratio, width protomerite: width deutomerite :: 1:1.1. Protomerite conoidal, dilated

at beginning of posterior two thirds, constricted at septum. Protomerite densest in posterior half. Deutomerite spherical to obovate, posterior end either rounded or slightly pointed. Nucleus large with one large karyosome in young, with many chromatic bodies in adult. Endocyte light brown. Epimerite spherical, hyaline, persistent on large animals free in lumen of intestine. Cyst and spores not known.

Taken at St. Joseph, Illinois. Host: *Amara angustata* Say. Habitat: intestine.

GREGARINES IN THE ORTHOPTERA

Five of the following species are new, one representing a newly created genus. New distribution records and new measurements are given for three species which are already known in the literature.

Gregarina nigra n. sp. (Fig. 14).—Sporonts biassociative, cylindrical. Maximum length of associations, 1000μ . Maximum length of sporonts 530μ , maximum width 180μ . Ratio, length protomerite: total length primitive :: 1:4. Ratio, width protomerite: width deutomerite :: 1:1.4. Protomerite a truncate cone angular at the free corners. Width equal to height. Widest at base, no constriction or a very slight constriction at septum. Protomerite of satellite scarcely flattened. Deutomerite cylindrical, broadly rounded posteriorly. Endocyte black. Nucleus not visible in vivo, spherical, containing many small karyosomes. Cysts and spores not known.

Taken at Urbana, Illinois. Hosts: *Melanoplus femur-rubrum* (deGeer); *M. differentialis* (Uhler); *Encoptolophus sordidis* (Burmeister). Habitat: intestine.

Gregarina stygia n. sp. (Fig. 15): Sporonts biassociative, obese. Maximum length of associations 360μ , length sporonts 180μ . Primitive and satellite of approximately the same length. Maximum width of primitive 100μ . Ratio, length protomerite: total length primitive :: 1:6. Ratio, width protomerite: width deutomerite :: 1:1.6 to 1:2. Protomerite hemispherical in primitive, flattened in satellite. Deutomerite of primitive broadly ellipsoidal, nearly as wide as long; of satellite widest in anterior half, tapering slightly. Nucleus small, spherical. Endocyte dark tan but not dense, nucleus visible in vivo in both primitive and satellite. Sarcocyte thicker in both protomerites than in the deutomerites. Trophozoite with a simple, small, knobbed epimerite. Cysts 150μ in diameter. Spores not seen.

Taken at Cold Spring Harbor, Long Island, N. Y. Host: *Ceuthophilus stygicus* (Scudder). Habitat: intestine.

Gregarina galliveri n. sp. (Fig. 16): Sporonts biassociative, maximum length of associations 590μ ; maximum length of sporonts 300μ , width 130μ . Ratio, length protomerite: total length primitive :: 1:5.

Ratio, width protomerite: width deutomerite : : 1.1:1. Protomerite flattened, broad and low. Three times as wide as high. Deutomerite of primate vase shaped, constricted at top, widening in posterior half. Deutomerite of satellite subspherical to ovoidal. Endocyte very dense in both protomerite and deutomerite, dark brown in color. Nucleus small, spherical, not visible in vivo. Cysts spherical, 350μ in average diameter. Spore ducts numerous. Spores not seen.

Taken at Oyster Bay, Long Island, N. Y. Host: *Gryllus abbreviatus* Serv. Habitat: intestine.

Gregarina illinensis n. sp. (Fig. 17): Sporonts biassociative, elongate cylindrical. Maximum length of associations 1100μ ; length sporonts 550μ , width 180μ . Ratio, length protomerite: total length primate : : 1:5. Ratio, width protomerite: width deutomerite : : 1:1.1 to 1.5. Protomerite dome shaped, slightly constricted at septum. Deutomerite elongate cylindrical, broadly rounded behind. Protomerite of satellite cupped at top for insertion of posterior end of primate. Nucleus large, spherical, with many small chromidial bodies. Endocyte dense, black in both protomerite and deutomerite. Cysts and spores not recovered from the host.

Taken at Urbana, Illinois. Host: *Ischnoptera pennsylvanica* (deGeer). Habitat: intestine.

Gregarina achetae-abbreviatae Leidy (Fig. 18): Sporonts biassociative, obese. Maximum observed length 500μ ; average sporonts 450μ long, 225μ wide. Ratio, length protomerite: total length primate : : 1:3. Ratio, width protomerite: width deutomerite : : 1:1.1. Protomerite hemispherical to subglobose, width twice the height. Slight constriction at septum. Deutomerite stout bodied, nearly as wide as long. Widest at shoulder where it is very little wider than protomerite. Posterior end truncate. Epimerite undescribed. Endocyte dense in deutomerite, less so in protomerite. Nucleus not visible in vivo and not seen. Cysts spherical, 250μ in average diameter. Spore ducts two to five in number, of maximum length 1000μ . Spores barrel shaped, $4.5 \times 2.25\mu$.

Taken at Haverford, Pa., and Urbana, Illinois. Host: *Gryllus abbreviatus* Serv. Habitat: intestine.

Gregarina rigida (Hall) Ellis (Fig. 19): Sporonts biassociative, stout bodied. Maximum length of associations 1425μ , average length 550μ . Sporonts 250 to 750μ long, 130 to 210μ wide. Ratio, length protomerite: total length of primate : : 1:3 to 1:6. Ratio, length protomerite: total length satellite : : 1:5 to 1:16. Ratio, width protomerite: with deutomerite : : 1:1.4. Protomerite somewhat flattened, width sometimes three times the height, generally less. Constriction at septum more or less indistinct. Deutomerite cylindrical or barrel

shaped, little wider than protomerite, ending in a broadly rounded or flattened square-cornered extremity. Endocyte very dense and brownish yellow in deutomerite, tan in protomerite. Epimerite a small, spherical, hyaline knob. Cysts yellow-orange, 300μ in average diameter, spore ducts short, ten or more in number. Spores extruded in chains, barrel shaped, $5\times 8\mu$.

Taken at Lincoln, Neb., Colorado Springs, Colo., and Urbana, Ill. Hosts: *Melanoplus femur-rubrum* (deGeer); *M. differentialis* (Uhler); *M. coloradensis* (?); *Encoptolophus sordidis* (Burm.); *Schistocerca americana* Burm.; *Melanoplus bivitattus* (Say); and *Hesperotettix pratensis* Scudder. Habitat: intestine and pyloric caeca.

This species was first described by Hall (1907) as *Hirmocystis rigida*. Crawley (1907) found it shortly after and named the species *Gregarina melanopli*. Ellis (1913) changed the name to *Gregarina rigida*.

Leidyana solitaria n. gen., n. sp. (Fig. 20): Sporonts solitary, cylindrical. Maximum length 500μ , maximum width 160μ . Ratio, length protomerite: total length :: 1:5 to 1:7. Ratio, width protomerite: width deutomerite :: 1:1.3 to 1:1.7. Protonomerite conical, dilated in middle portion, constricted deeply at septum. Protonomerite slightly wider than high in adults. Deutomerite cylindrical to elongate ellipsoidal, sometimes tapering, rounded posteriorly. Endocyte of protonomerite pale tan, translucent, of deutomerite very dense, black in transmitted light, the two parts very plainly demarked, nucleus not visible in vivo, spherical, with one or two small karyosomes. Epimerite a large, globular, hyaline knob on a short, slender stalk. Cysts spherical, 350μ in diameter (including the transparent covering). Dehiscence by spore ducts one to twelve in number. Spores given out in chains, barrel shaped, 3 by 6μ .

Taken at Cold Spring Harbor and Oyster Bay, L. I., N. Y., Haverford, Pa., and Urbana, Ill. Host: *Gryllus pennsylvanicus* Burm. Habitat: intestine.

This species was described by Crawley (1907) under the name *Stenophora erratica*. The mode of cyst dehiscence, however, precludes the possibility of its belonging to the family Stenophoridae. I have placed it in a new genus under the family Gregarinidae, characterized as follows: *Leidyana* n. gen. Sporonts solitary, epimerite a simple globular knob, dehiscence by spore ducts, spores doliform.

I should restrict the genus *Gregarina* to biassociative sporonts only, the other characters being identical with those of the new genus.

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EXPLANATION OF PLATES 1 AND 2

Fig. 1.—Sporont of *Stenophora diplocorpa* n. sp. from camera lucida drawing of the original.

Fig. 2.—Sporont of *Stenophora impressa* n. sp.

Fig. 3.—*Stenophora lactaria* n. sp.

Fig. 4.—*Amphoroides calverti* (Crawley).

Fig. 5.—*Gregarina katherina* n. sp.

Fig. 6.—*Gregarina barbarara* n. sp.

Fig. 7.—*Gregarina globosa* n. sp.

Fig. 8.—*Gregarina monarchia* n. sp.

Fig. 9.—*Gregarina intestinalis* n. sp.

Fig. 10.—*Gregarina gracilis* n. sp.

Fig. 11.—*Gregarina tenebrionella* n. sp.

Fig. 12.—*Gregarina fragilis* n. sp.

Fig. 13.—*Steinina rotunda* n. sp., a trophozoite with epimerite

Fig. 14.—*Gregarina nigra* n. sp.

Fig. 15.—*Gregarina stygia* n. sp.

Fig. 16.—*Gregarina galliveri* n. sp.

Fig. 17.—*Gregarina illinensis* n. sp.

Fig. 18.—*Gregarina achetae-abbreviatae* Leidy.

Fig. 19.—*Gregarina rigida* (Hall) Ellis.

Fig. 20.—*Leidyana solitaria* n. gen., n. sp.

PLATE 1

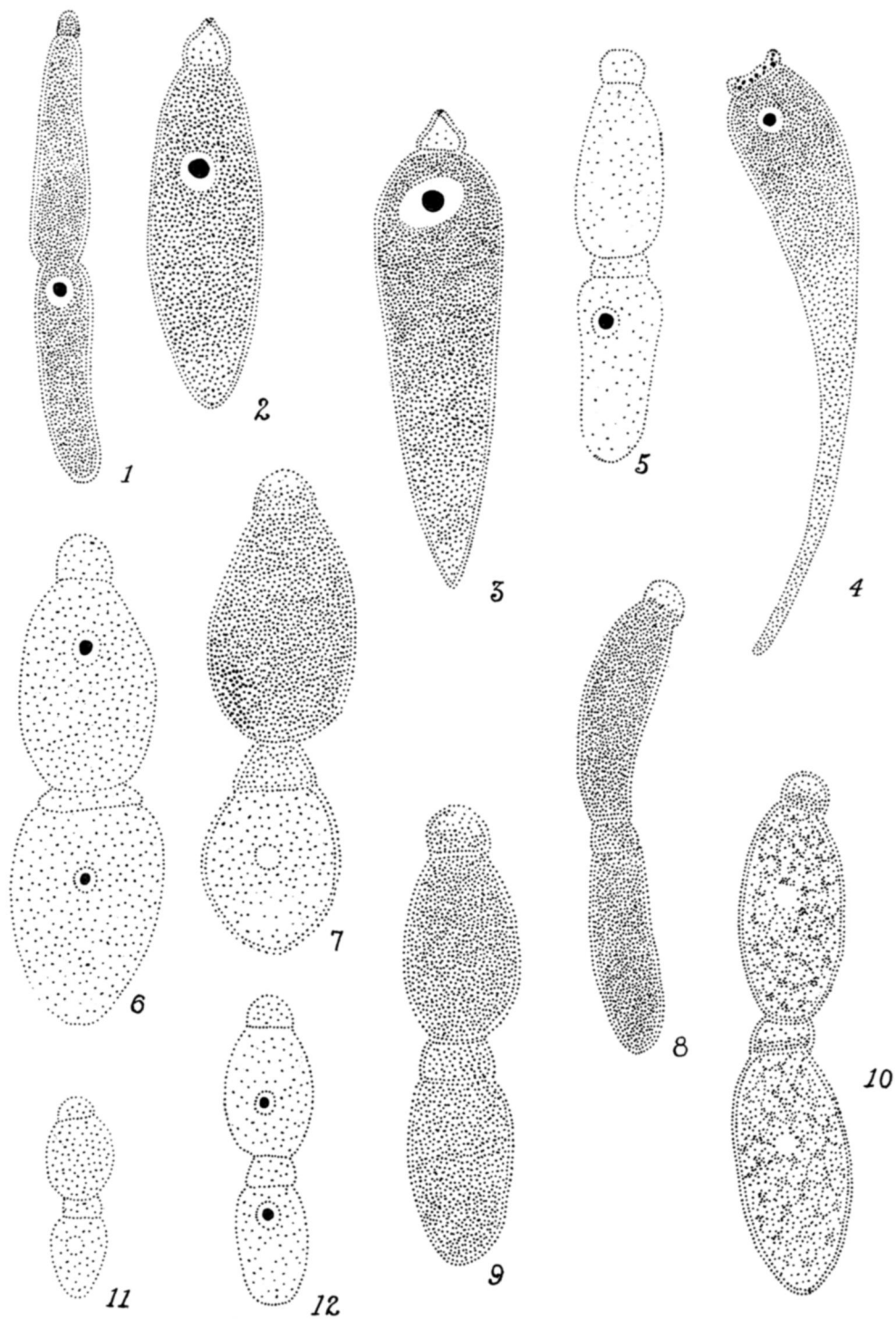
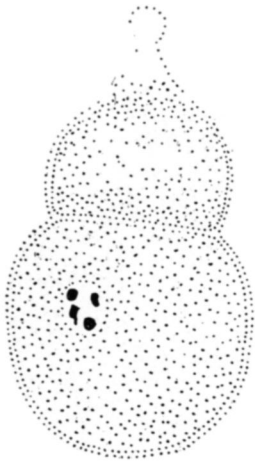


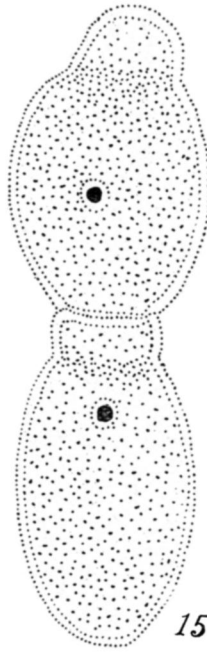
PLATE 2



13



14



15



16



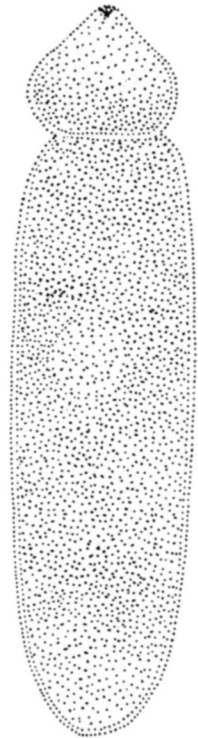
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